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WHAT IS ACCURACY IN ELEMENTARY ARITHMETIC?

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In a recent, widely circulated article, under the title "Arithmetic for Children under Twelve," we were told the old, old story—so old, forsooth, as to appear new again to its writer—viz.: "The chief value of number work lies in its contribution to the habit of accuracy, and children are not and cannot be accurate in the earlier stages of their development, as test investigations show." A little farther along in the same article we are informed: "Number work for this period should consist of . . . . (*b*) exercises in computation to form the habit of accuracy."

A different writer in another journal gives us a glimpse of personal administrative practice. He writes:

> For some years I have been accustomed to insist that the arithmetic work which calls for children in the lower grades to pursue steps of reasoning was positively wrong. Very little of it is done in K——— schools. We use all diligence to make our children quick and accurate in fundamental conceptions as pure memory work.

The writer obtained his elementary maltreatment in arithmetic from twenty-five to thirty-five years ago, in the schools of the same state in which the gentleman who penned the last quotation is administering his notions of elementary education in arithmetic, and under teachers who held this same conception of the educational function of arithmetic. It is truly amazing how an error, that is easily grasped and administered, does persist in propagating itself! Obviously, there are still pupils in this state who, like the writer, will have to unlearn most of that on which they spent time in school, and slowly awaken to a consciousness, after they have left school, that, as regards the arithmetic, their time in school was worse than lost. But if teachers learn with difficulty their true functions and duties, administrative officers seem to learn with difficulties doubled and twisted, what is their duty touching the arithmetic.

In a widely used arithmetic of recent date, whose chief distinction lies in the twofold merit of exhibiting (1) how fully elementary arithmetic may be formalized and mechanized, and (2) how necessary it is to prop up such a treatment with braces in the form of pedagogical notes to the teacher to excuse the author for much of his folly, we read the hysterical admonition: "A bank clerk who makes one error a day in carrying out his balances, which he does not himself discover and detect, would not retain his position." Again: "Remember that any inaccuracy in solving business problems makes the work valueless." Thus, after carefully and successfully blindfolding the pupil to the thought-value of arithmetic, the author takes off the blindfold at the foot of each page and flaunts the scarecrow of accuracy before the child.

The tenor of these quotations is in one form or another, the dominant note nowadays of discussions on arithmetic in the schools. Administrative officers seem to have a peculiar fondness for this view. Ask the teacher of any non-mathematical subject what ought to be attempted in early arithmetic, and you are usually met with the prompt reply that speed and accuracy are the things. Furthermore, many old-line teachers, most young and inexperienced teachers, and amateur students of elementary education generally, dismiss the arithmetic problem in the early grades with the same off-hand solution. Perhaps some attention to the matter will be pardoned here.

It is well to note that general acceptance of a view is not infallible proof of its soundness. In many cases it indicates almost nothing at all. The school public inherits tendencies, dons prevailing fashions, and contracts contagions as certainly and as easily as do our physical organisms. Before acknowledging obeisance to a prevailing idea, it is the part of wisdom to examine it. We cannot with justice be confronted with that dreaded charge of disrespect for tradition until we refuse to accept a well-grounded one. Let us then inquire a little into the nature of this thing which we call "accuracy" in arithmetic work.

First of all, accuracy in arithmetic is a mental, and neither a manual nor a mnemonic attribute. An element of thinking is a *sine qua non* of accuracy. Without thinking it is not only impossible "to contribute to the habit of accuracy," but it is impossible also even to generate the notion of accuracy. Pure memory work can no more beget even the idea — to say nothing of the habit — of accuracy than can health beget the conception of sickness. "He remembers inaccurately" is a contradiction, and "he remembers accurately" is tautology. He either remembers or he does not. There are no gradations of remembering as there are of temperature. This is especially true of formal number facts. Pure memory work does not touch accuracy at any point. It is absurd to talk of making "children accurate in fundamental operations as pure memory work." The sufficient reason that diligence spent in attempts to make children accurate in pure memory work is wasted is that the impossible is attempted.

In the next place, accuracy involves an external as well as an internal element. There must be a comparing and a judging between two factors before we can assert accuracy of any sort of work. In short, accuracy is predicable only after a comparison, and is itself a judgment. In arithmetic the two explicit or implicit factors are an idea and an effort to express it. If either of the factors is lacking, the very notion of accuracy falls to the ground.

Moreover, it is important to note that unless there be degrees of closeness, or adequacy, of expression of thought, accuracy has no meaning at all. Accuracy, in the only legitimate sense in arithmetic, means the degree of closeness of expression to idea — the adequacy of assertion to thought. Much of arithmetic is a language, an agency for expressing quantitative thought. The rest of it, and of course much the major part of it, is the thinking itself. If the pupil's expression is adequate to his number-concept in any given situation, the same mental satisfaction is felt by him in handling it as is felt by the most experienced adult who has struggled successfully to give adequate utterance to his more precise notions. The same wholesome issue in character, the same educative effect, results in one case as in the other. The idea that accuracy in number work means the degree of closeness of approach of expression to absolute correctness is useless, unattainable, and has not even the saving virtue of being correct. The most accurate users of language can do nothing more than express adequately their conception of the truth. When, therefore, we have to do with the formal aspects of arithmetic, the language side of it, we are attempting to draw aim on an invisible, and intangible, object if we insist that accuracy shall mean adequacy of expression to absolute truth. The constant effort to express one's ideas with precision, however, pushes the ideal continually nearer and nearer to the absolutely true. In other words, the use of precise language eventuates in the accurate *thinker*. The teacher can influence more accurate *thinking* only by seeing to it that the pupil "say just what he thinks." This attempt to express one's idea with perfect fulness is the paramount problem for the school. It is no more than the youngest pupil can do, and no less than he should be continually exercised in doing. The core-problem, be it remembered, is not a matter of symbols and technique so much as it is a problem of the defining of ideas.

The current conception that accuracy in number work is synonymous with a sort of target-practice precision grows naturally out of the thought that school work in arithmetic consists in fixing in memory the facts of the tables. The sums and products are remembered, or forgotten, and the tendency has solidified into a custom of looking upon that student as accurate who has only a retentive verbal memory. Test studies show pretty conclusively that the verbal memory is capable of, perhaps, the least development of all of the mental faculties. As a matter of fact, in arithmetic, the only sort of memory that needs looking after at all — and it should be looked after most diligently — is the rational memory. The two kinds of memory are rarely strong in the same person. The rational memory has little difficulty in holding a fact after it has been brought into relation with kindred truth. The strong rational memory implies the possibility of setting up relationships at numerous points with ideas already in the mind. The fuller the mind, the greater is the task of organizing the new element of knowledge into right relationships with what is already known. The thoughtful student is the slow student, because his task of assimilating the new idea is relatively great. It is this fact that puts truth into the admonition: "Pick your future student of mathematics from the slow arithmetic pupils." For from start to finish the would-be mathematician is he who has not only knowledge, but has "the knowledge that *knows that it knows.*"

The true conception of accuracy is secured by both teacher and pupil through measuring and the use of measurements in arithmetic work. The question naturally arises very soon: With what degree of accuracy should the measurements be made? This question must be answered by the teacher from two points of view, and by the pupil from only one. The teacher will ascertain, first, what is the smallest unit of which the pupil has, or can readily form, an adequate working conception. It is useless for the learner to attempt to work with a smaller unit than he can image. This sets the natural limit from the educational point of view.

In the next place, both teacher and pupil must study the question of the limit of refinement to be sought, from the view-point of the nature of the problem. If the problem is to find the number of plants needed for his flower-bed, it would be senseless to carry results to fractions. If he wants to cut a member for the frame of his playhouse, an eighth or a sixteenth of an inch becomes a serious matter, and must be attended to. Just here, we are reminded by some timid teacher, consists the difficulty in such work. No hard and fast rules can be set, and those of us who have not yet risen above rule and rote work grow quixotic at the imagined difficulty. How our arithmetic would thrill with life, if we could but see that the fine quality of training in arithmetical judgment, under purpose, which such questions furnish the pupil contains the very essence of educational merit! In the consideration of just these questions consists the difference between thought-work and mere words and symbols. Admitting such questions into the arithmetic class goes far toward generating, fostering, and strengthening the pupil's confidence in the truth that arithmetic is only organized common-sense. His number experiences thus become continuous with his life out of school.

We may now summarize the points of this paper as follows:

Accuracy in school work in arithmetic should mean the *degree of adequacy of expression to idea.*

The criterion for the measure of accuracy to be striven for is twofold: first, the ability of the pupil to form a *working image of the smallest (or largest) unit* employed in the problem; second, the *nature of the problem* itself.

Finally, neither the conception, nor habit, of accuracy can be generated in the pupil by formal memory work alone; but with the correct conception of accuracy the young pupil of arithmetic can be just as accurate and just as truly accurate as the most experienced adult.